Ventilator Terminology Review Handbook

A Fundamental Review of Ventilation Terminology

History

In the early days of widespread artificial ventilation of humans, there were two main applications; ventilation of patients who had become incapable of breathing for themselves due to illness or accident, and the ventilation of patients who needed temporary ventilatory support during anaesthesia.

The ventilation of those incapable of breathing was often performed by mechanical ventilators that delivered a set ventilatory pattern continuously without consideration of the patient's own efforts.

Artificial ventilation of patients during surgery was largely performed manually by means of an anaesthesia bag. For many years, anesthesiologists were reluctant to use mechanical ventilators because it was believed that only the 'educated hand' of the anesthesiologist could interact sufficiently sensitively with the patient's needs according to the depth of anaesthesia.

However, modern ventilators have been developed to a stage where they are now capable of replicating or exceeding the best 'educated hand', but the terminology used to describe their operation has not kept pace with these developments.

Review

With the advent of modern microprocessor controlled ventilators with active exhalation valves, or a similar facility, the ventilator and patient no longer work in isolation. The ventilator can now be set to adapt to the patient's needs rather than forcing ventilation on a patient. As a result, one needs to view the interactions using a systems approach—the patient-ventilator system.

The current "language" used in describing ventilator function has therefore been reviewed from first principles. This analysis has shown that, in general, current terms are used in the correct context but that explanations and definitions are inconsistent and suffer from the absence of a generally accepted conceptual model, based on the fundamental principles of artificial ventilation. To correct this deficiency, a new ontological framework has been developed that was built up from first principles. Some new concepts are introduced, but wherever possible existing terms have been retained.

The terminology based on this new framework is described in a following set of figures.

Two perspectives

One important outcome of the review was the realization that it has become current practice to describe artificial ventilation function in terms of the waveform displaying the outcome of the ventilation. However, before the ventilator can start ventilating a patient, it must be properly set up and at this stage, the mindset of the operator has to be looking ahead and thinking how the ventilator should be set to respond to what the patient might do, rather than looking backwards to see how the patient interacted with the ventilator. These two different perspectives require adjustments to the terminology used and so this presentation will make this distinction wherever necessary.

From the setting perspective, the operator has to be thinking in terms of what must be made to happen and when; and how the ventilator should be set to respond to any possible patient breathing activity. In essence, the operator has to be thinking in the same way as when manually ventilating the patient, that is, trying to replicate the thought processes behind the experienced 'educated hand'.

When ventilating a patient by hand, an experienced person will interact with the patient instinctively, but subconsciously will decide:

- when to squeeze the bag solely to ensure that the patient receives ventilation, irrespective of what the patient is doing,
- if the patient is making any attempts to breathe, when to squeeze the bag in synchrony with the patient's efforts, and

in both cases, how to control the squeeze once started.

When *setting a ventilator* the operator should be thinking of the machine as doing the same thing, i.e.:

- what is the minimum rate at which the ventilator must deliver a breath in order to achieve adequate ventilation,
- how should the ventilator respond to a patient's breathing efforts between the set breath deliveries, and
- in both cases, the form and duration of the delivery.

With this model:

1. Each event that is equivalent to that of "deciding to squeeze the bag" solely to maintain the necessary ventilation is classified as an '***assured occurrence***',

2. Any detectable indication that the patient is starting a spontaneous breath is classified as a '***spontaneous occurrence'***,

3. The ways in which the ventilator can replicate the various basic pressure/ flow patterns that can be achieved during the course of squeezing the bag are classified as '***breath-types'***, and

4. The ventilator algorithm that:
(i) generates ***assured occurrences***;
(ii) implements the set response to ***spontaneous occurrences***; and
(iii) initiates the selected ***breath-types***:

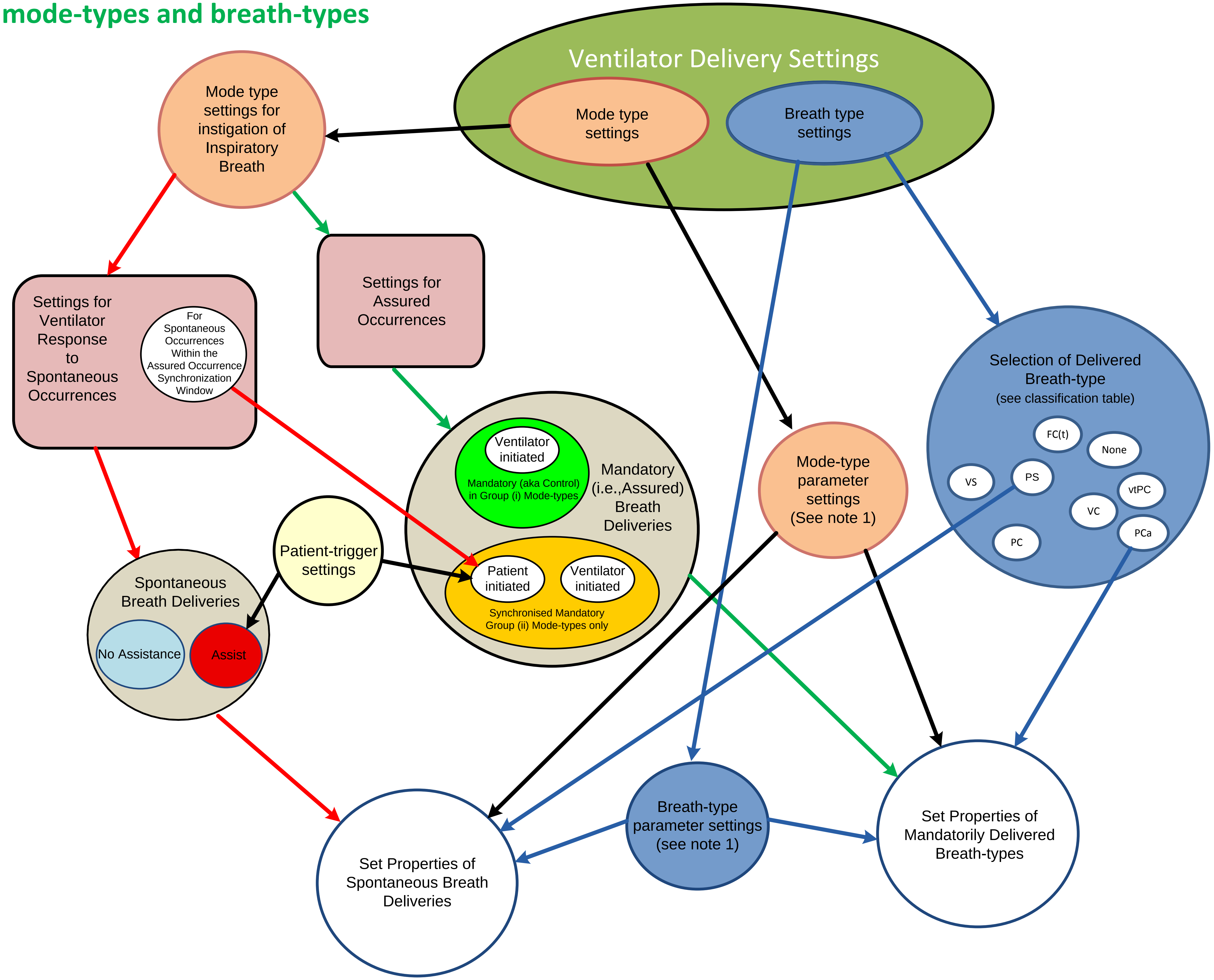
is classified as a ***mode-type***.

As a result, when setting up a ventilator, prior to patient use, and when making changes in ventilation, one must select the ***mode-type***, ***breath-type(s)*** and their respective properties (e.g. volume, flow, pressure...). Depending on the ***mode-type***, one or more different ***breath-types*** may be utilized.

These basic thought processes have been incorporated into a universally applicable network diagram that shows the fundamental pathways that have to be always followed in the process of setting a ventilator to deliver any of the modes of operation that may be offered by the manufacturer.   The arrows indicate the pathways and the coloured shapes show the options available for selection before moving on to the next shape. All the pathways end with one of two uncoloured shapes, at which point the complete pattern of ventilation has been set. In the final pages of this handbook the application of the diagram in the setting of a wide range of ventilation modes is shown.

To help in the understanding of the network diagram the next set of figures provides a review of the basics of human ventilation and introduces the new terms and definitions that are necessary.

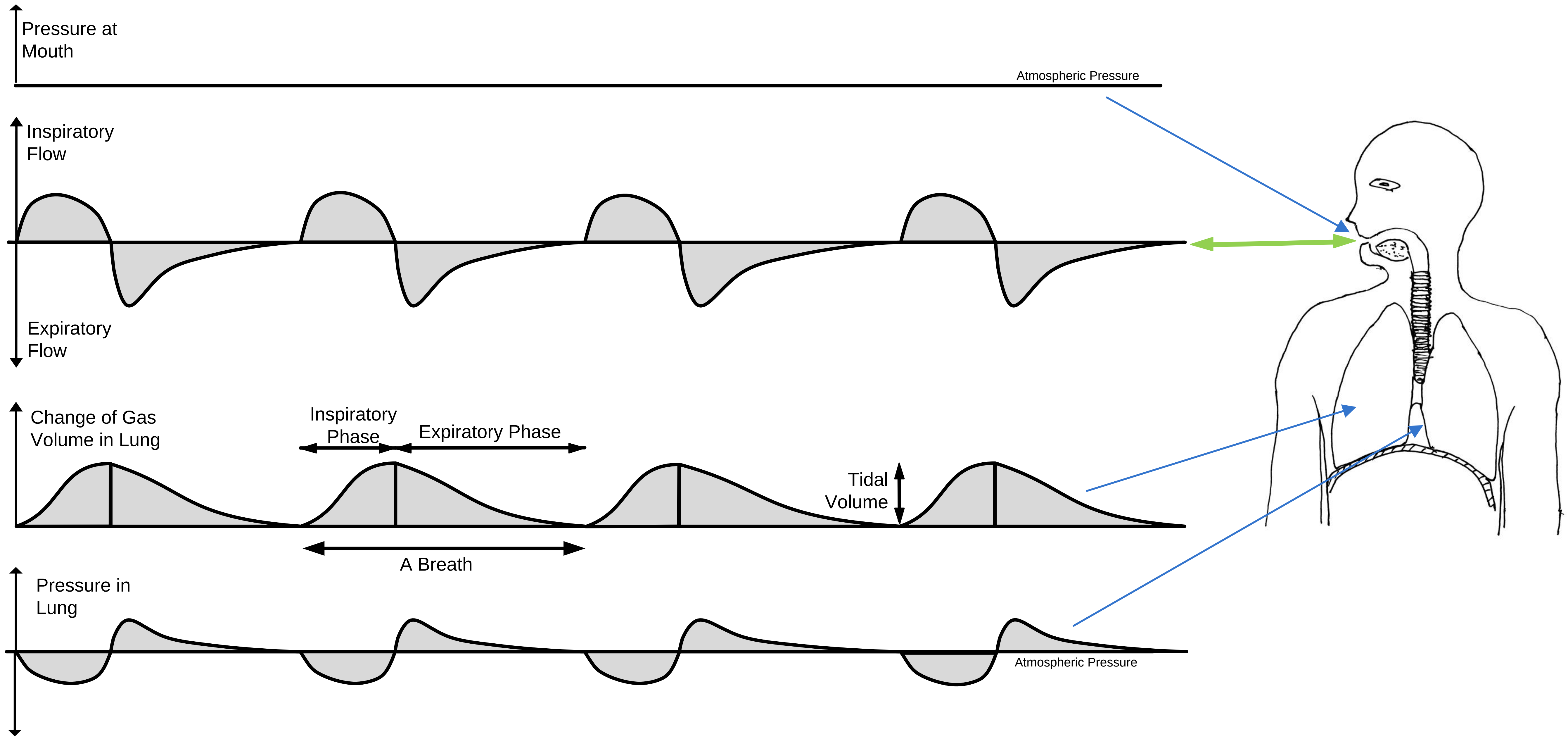
Master template for all mode-types and breath-types



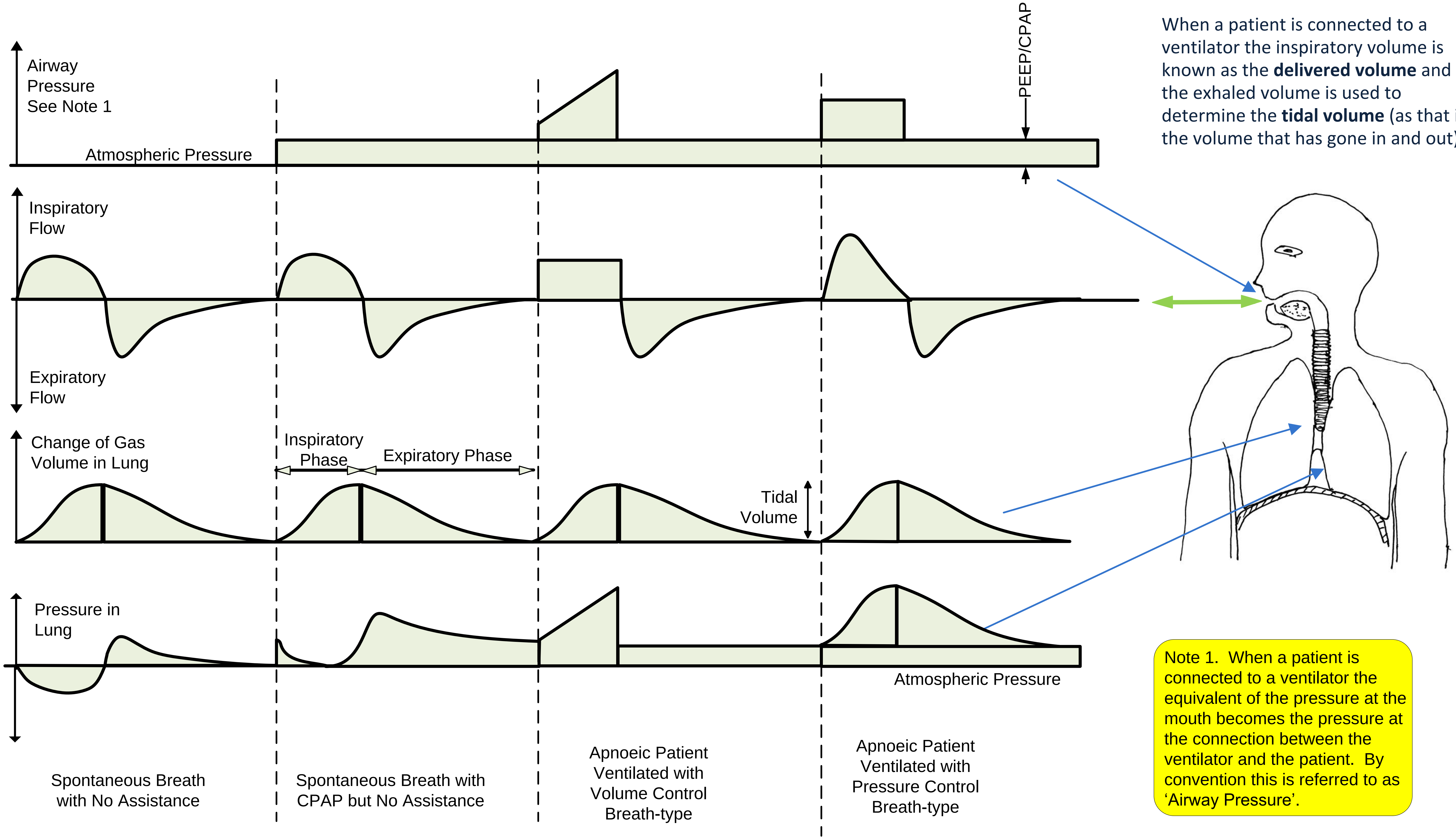
A Breath

Typical breath waveforms of natural spontaneous breathing

***Breath**: An increase in the volume of gas in the lungs resulting from an inwards gas flow though the airway (inspiration) paired with a decrease in volume resulting from an outward flow (exhalation), thereby ventilating the lungs in order to deliver oxygen and remove CO_2. This volume of gas that has entered and left the lungs has been named the **tidal volume**.*



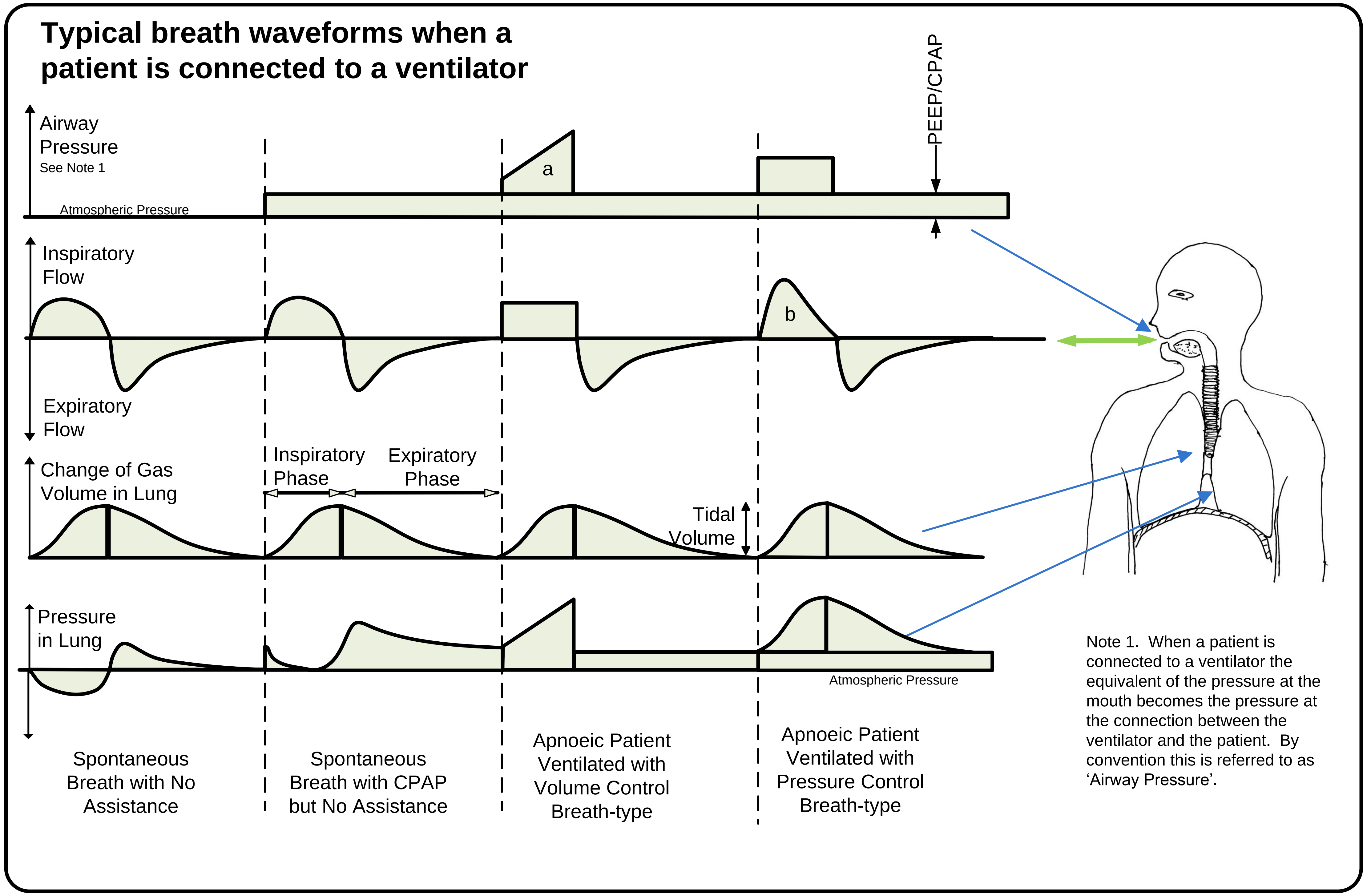
Typical breath waveforms when connected to a ventilator



When a patient is connected to a ventilator the inspiratory volume is known as the **delivered volume** and the exhaled volume is used to determine the **tidal volume** (as that is the volume that has gone in and out).

Note 1. When a patient is connected to a ventilator the equivalent of the pressure at the mouth becomes the pressure at the connection between the ventilator and the patient. By convention this is referred to as 'Airway Pressure'.

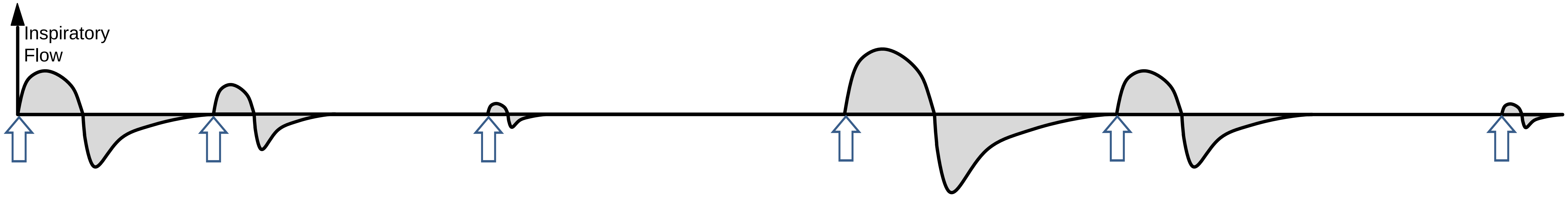
A Breath-type



The airway pressure waveform illustrates that when the patient is breathing with no assistance there is no change of pressure throughout the respiratory period although when CPAP is provided there is a continuous positive baseline pressure.
There is no pressure change because the ventilator is automatically compensating for any effects of internal resistance
For the ventilator to be able to provide some or all of the work of the patient's breathing it is necessary for the airway pressure to be elevated above any baseline positive pressure, during the inspiratory phase. The pattern of this elevated pressure is classified as a breath-type. This is not a type of breath, it is solely a name for the characteristic pressure pattern that has to be applied to the airway during the inspiratory phase to cause a required inspiratory flow pattern in a passive lung. In practice, the pressure pattern is generated either directly by means of a pressure controller or indirectly by means of a flow controller that automatically adjusts the airway pressure to achieve the required flow value. The primary classification of breath-types is therefore by either flow or pressure control.
Any patient inspiratory effort and changes to airway resistance and lung compliance will modify the waveform of the non-controlled parameter (a or b).

Breath-type*: The term used to delineate the elevated pressure/time pattern that is selected to be intermittently generated by a ventilator at the patient's airway with the intention of assisting or controlling the inspiratory phase of a breath. Its primary classification is by means of the controlled parameter during delivery, i.e., flow or pressure. Its secondary classification is by means of the criterion (or criteria) by which it will (or may) be terminated, e.g., time, flow, pressure.*
Note: The initiation of the delivery of a selected breath-type is always taken to be a function of the selected mode-type.

Example of flow wavefom pattern during irregular spontaneous breathing



A Mode-type

If there is no breathing activity by the patient the ventilator can be set to deliver a set breath-type at a set frequency but if the patient is breathing erratically, such as shown above, the operator may have to ensure that a set breath-type is delivered at the required frequency.

With the revised terminology, the process of ensuring that the ventilator instigates the delivery of this set breath-type at the set frequency is classified as the setting of ‘assured occurrences’. The concept here is that in setting such assured occurrences the operator can be assured that a selected level of temporarily elevated pressure will be applied to the patient’s airway at the set frequency; hence have assurance that the patient will be ventilated to a set level even in the case of apnoea.

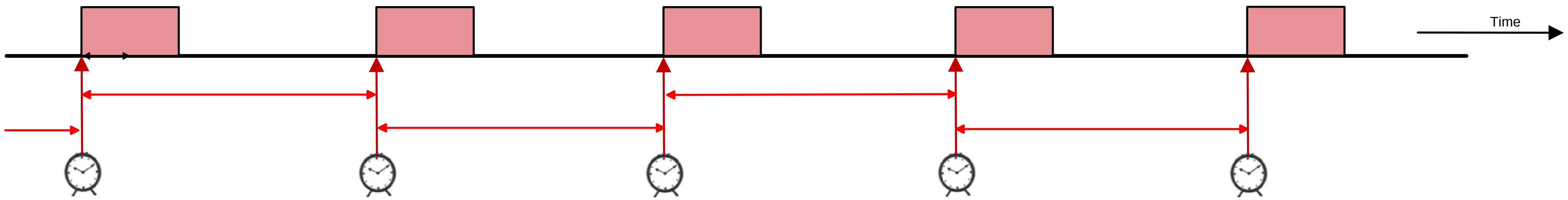
Modern ventilators can also be set to respond to the onset of each spontaneous breath. They cannot anticipate how large each spontaneous breath is going to be and therefore can only be set to respond to the first detectable signs of a breath. Such a detectable sign is classed as a ‘spontaneous occurrence’ and each one is denoted above by a white arrow.

***Mode-type**: a name for a specific, identifiable pattern of when selected breath-types are applied and generally how the ventilator interacts with the patient.*

Mode-type Functions

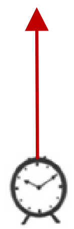
Assured Breath Deliveries

At its most invasive the ventilator can be set to deliver the total required ventilation as a result of the assured occurrences – with any spontaneous occurrences being ignored. Such a ventilation sequence is illustrated below.



In this illustration just one breath-type has been selected to be delivered

The coloured rectangle represents the selected breath-type and the colour denotes that it will be initiated as a result of an assured occurrence. It will therefore become an assured delivery of the selected breath-type. Convention has classified such a delivery as being mandatory and hence the resulting breath, as displayed on a waveform (an observation), has been named as a mandatory breath. In this nomenclature, a mandatory breath is only ever as a result of a mandatory occurrence in the sense of an assured occurrence .

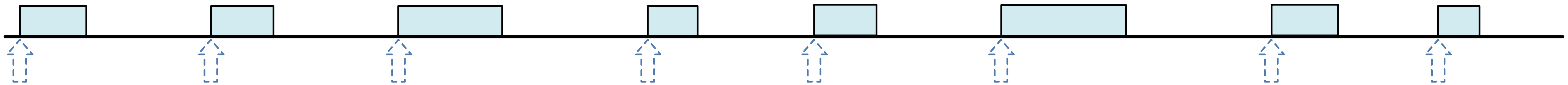


The red arrow represents an assured occurrence and the clock signifies that this is set to occur at a timed interval from the previous assured occurrence.
This timed interval will result from a set frequency (60/f) but certain mode-types, such as MMV, will have constant control of this frequency to assure the operator of optimum ventilation based on specified relevant monitored signals.

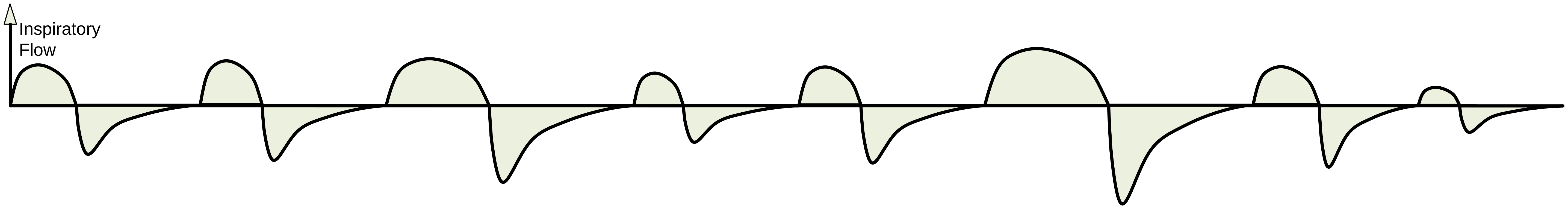
Spontaneous Breath Deliveries

Set to its least invasive mode, the ventilator only responds to spontaneous occurrences and generates no assured occurrences. If a breath-type is selected this is initiated by each spontaneous occurrence. If no breath-type is selected the ventilator delivers the flow demanded by the patient but maintains a constant airway pressure – either at atmospheric pressure or at a constant positive pressure (CPAP).

Setting Perspective



Observed Flow Waveform



In this illustration a pressure support breath-type has been selected. This provides support by maintaining an elevated pressure during the inspiratory phase which is terminated if the patient makes an expiratory effort.
The top delivery pattern illustrates the operator's perspective when setting the ventilator. The waveform below it illustrates a typical resultant respiratory flow pattern.

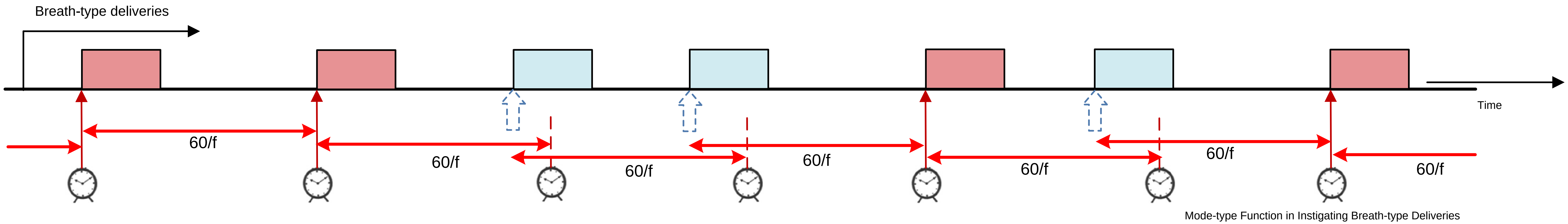
The coloured rectangle represents the selected breath-type and the colour denotes that its initiation was solely in response to a spontaneous occurrence. It is clear that a ventilator cannot take 'spontaneous' breaths – only a patient can do that – but the ventilator has to deliver the gas demanded by the patient's breathing efforts. Such a 'spontaneous breath delivery' can either 'assist' the patient's inspiration by the initiation of a selected breath-type or simply passively provide the required flow with 'no assistance' (sometimes called a demand delivery).
Convention has classified such a delivery as being an 'assisted spontaneous' delivery and hence the resulting breath, as displayed on a waveform (an observation), as an assisted spontaneous breath.
In this nomenclature a spontaneous breath delivery can only be initiated by a spontaneous occurrence although it may assist the delivery by means of the same breath-type as that selected to provide 'assured deliveries'.

This arrow is used to represents an envisaged pattern of 'spontaneous occurrences'. It is shown with a broken outline in this view because they represent the 'what if'.

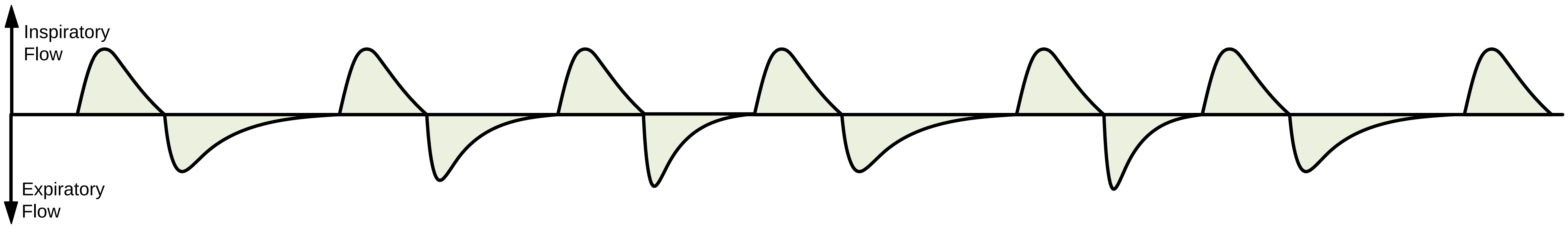
Mixture of Assured and Spontaneous
Breath Deliveries

a) Assist/Mandatory (A/M) Mode-type

Setting Perspective



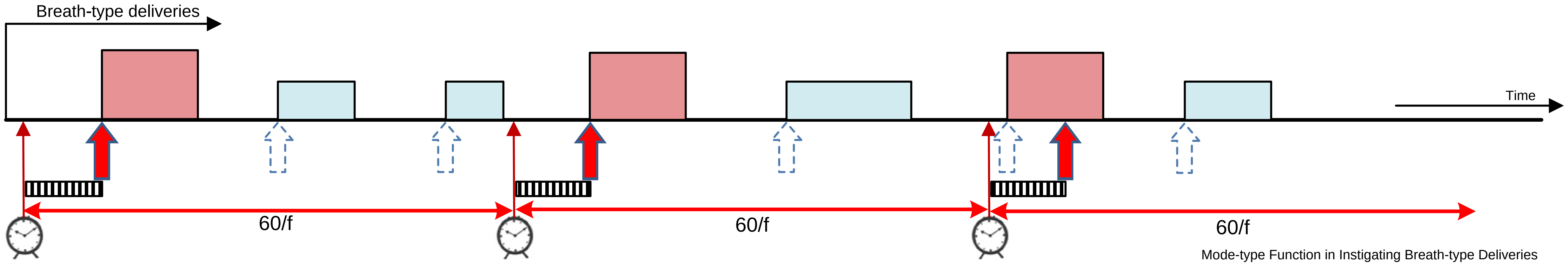
Typical consequent Flow Waveform



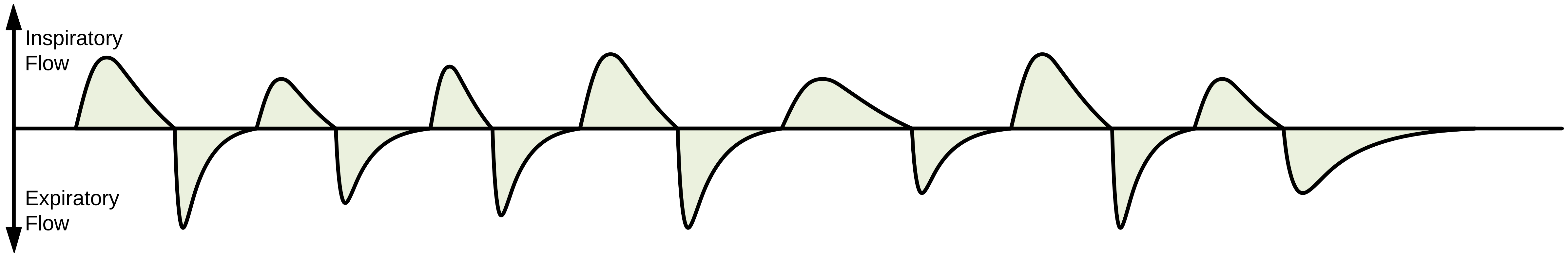
Mixture of Assured and Spontaneous Breath Deliveries

b) Synchronised Intermittent Mandatory Ventilation (SIMV) Mode-type

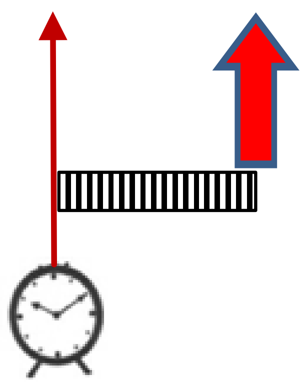
Setting Perspective



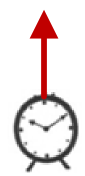
Typical consequent Flow Waveform



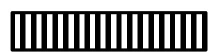
Synchronization is necessary in mode-types with more than one breath-type if breath-stacking is to be avoided when the mode-type algorithm delivers one of the breath-types at a set frequency. This is normally achieved by providing a period following the timed instigation, during which, either the patient can complete the exhalation of a breath inspired just before instigation or the delivery can be initiated in response to any spontaneous occurrence. In the absence of any spontaneous occurrence, the delivery is automatically initiated at the end of the period. The delay period is named as a ‘synchronisation window’.



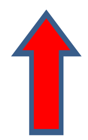
This composite symbol represents the function of a synchronization window. After instigation by an assured occurrence it provides time for the exhalation of any previously inhaled breath but responds immediately to a spontaneous occurrence by initiating the already assured breath-type delivery.



The red arrow represents an assured occurrence and the clock signifies that this is set to occur at a timed interval from the previous assured occurrence. Where a synchronisation window is necessary the assured occurrence instigates the breath delivery by opening the synchronization window



This symbol represents the delay period that has been named as the synchronization window.



This symbol represents the ventilator initiation of the assured breath-type delivery in the absence of any spontaneous occurrence during the synchronization window.

Breath-types

As has already been explained, breath-types are classified primarily according to the delivery control means and secondarily according to the means of termination. The table shows the main classifications and the generic names that have been given to the common sub classes.

Breath-Type Classification Table

Breath-Type Basic Classifications	*Flow-Control Group*	*Pressure-Control Group*
Examples of Generic Breath-Type Names	FC(t) = VC, FC(p)	PC, PC(f,t) = PS, PCa[2], PC(f/t) = PS/PC[3], , PPS
Generic Prefixes & Suffixes for Derivatives of Generic Breath-Types	-Pressure-Limited, VT- [1]	VT-

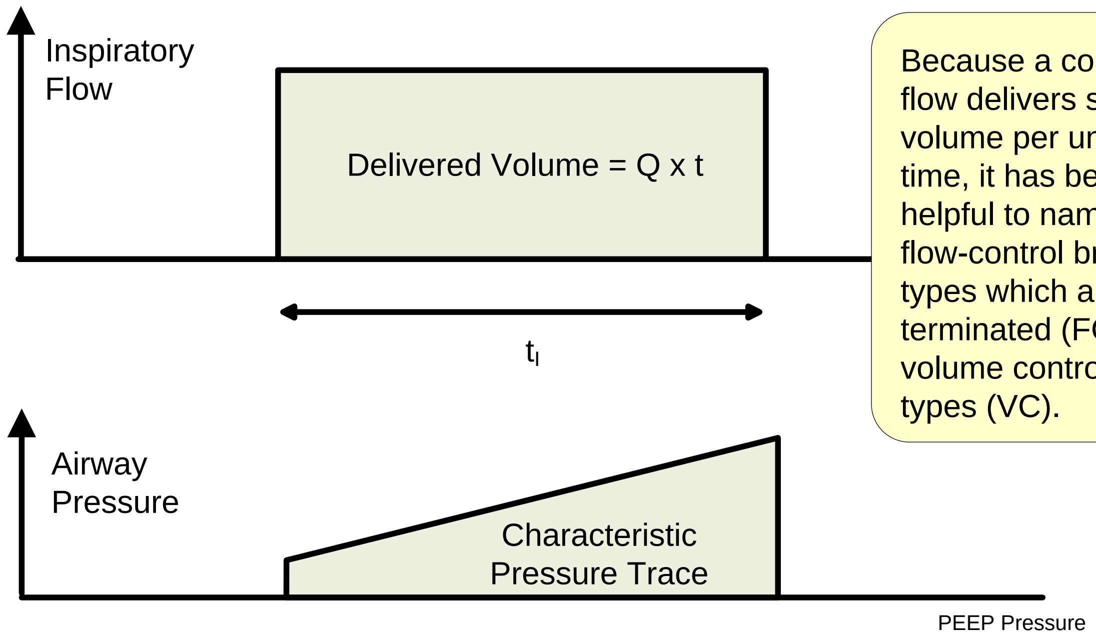
1 Volume targeted (could apply to FC(p))

2 A PC breath-type that allows free exhalation at any time

3 Terminated by flow if patient initiated and time if time initiated

Breath-type waveforms

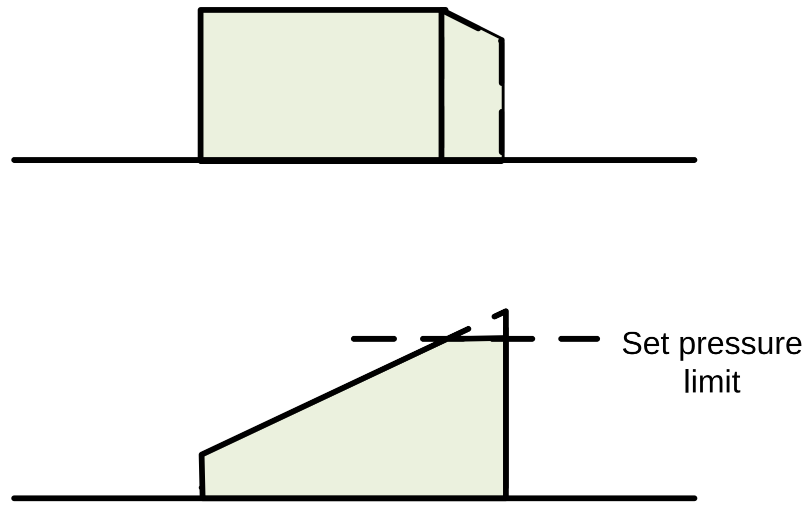
VC Breath-types



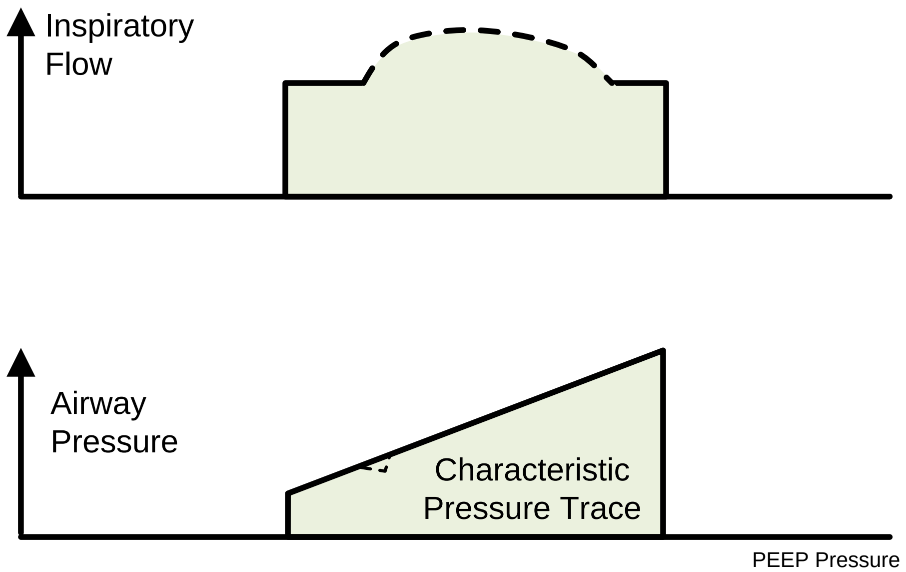
VC

Because a controlled flow delivers set units of volume per units of time, it has been found helpful to name those flow-control breath-types which are time-terminated (FC(t)) , as volume control breath-types (VC).

This is a VC breath-type with a settable pressure limitation means that is independent of the high pressure alarm.
If the set volume is not achieved an appropriate alarm is generated.



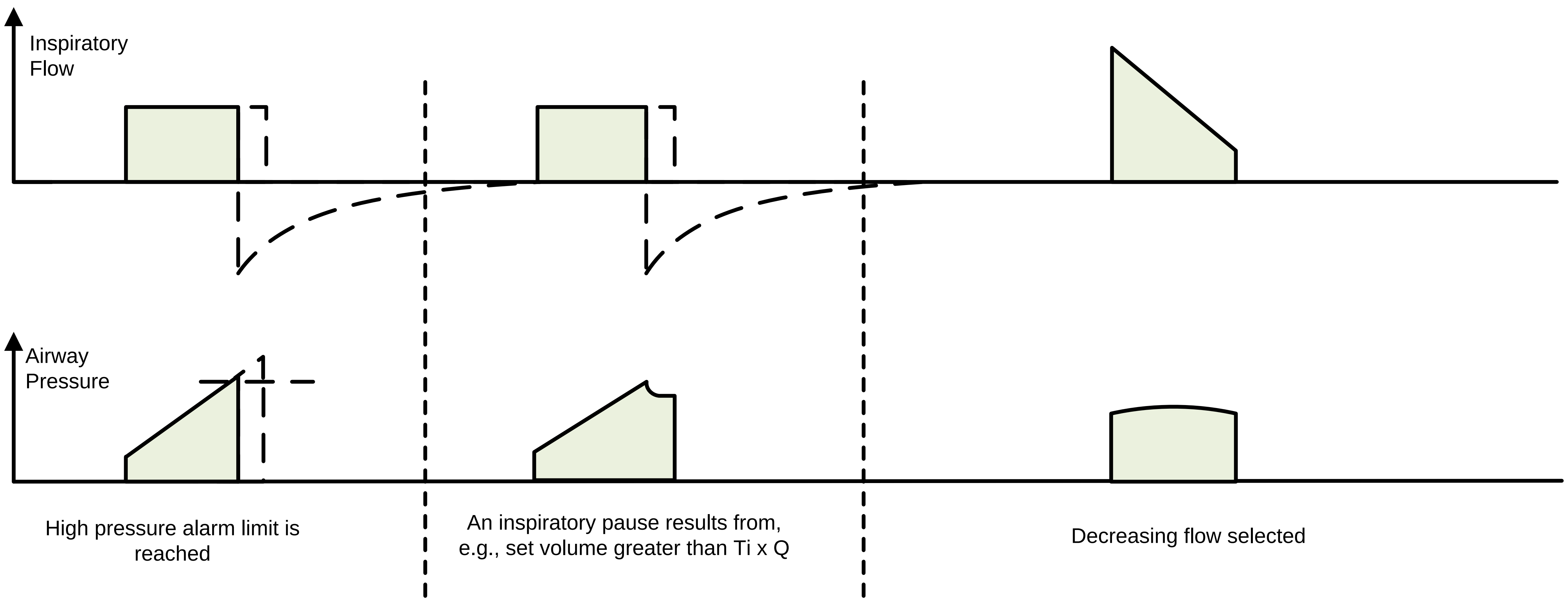
VC-Pressure Limited



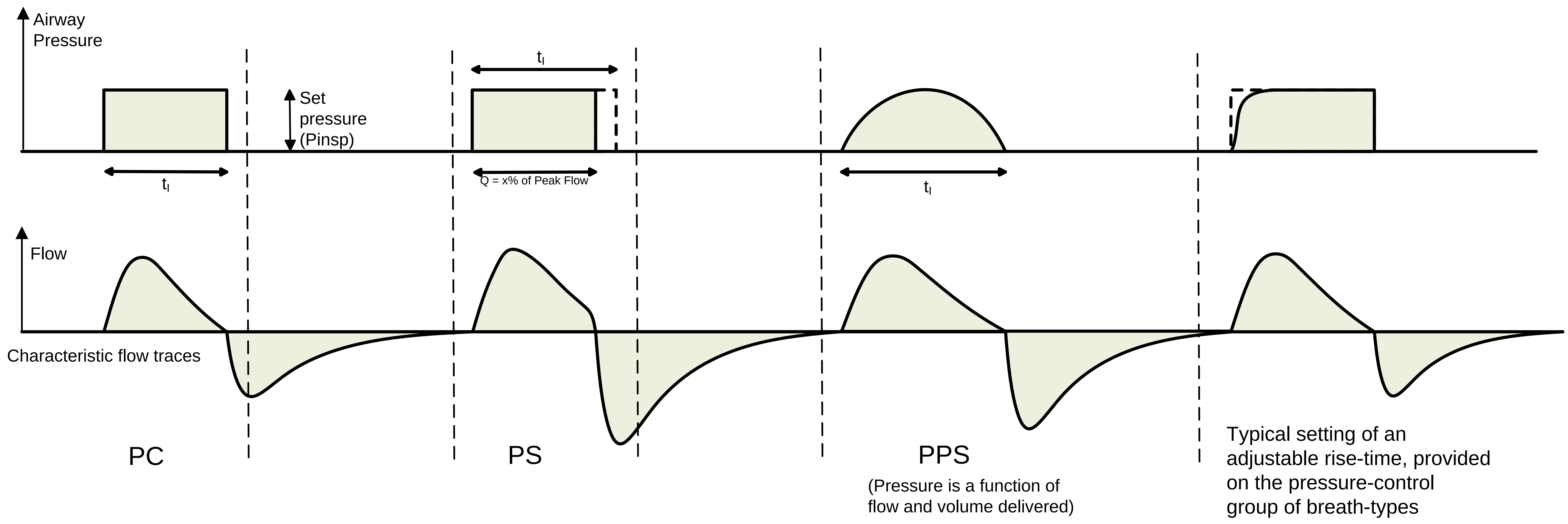
VC-PS
(Dual Control)

With this dual control breath-type, if the patient demands an inspiratory flow in excess of the set flow the ventilator responds to the resultant pressure drop by changing the breath-type to PS in order to maintain the pressure trace trajectory. It reverts to VC when the demand flow matches the set value.
The termination of the breath is determined by the stated criteria for the particular implementation; it may terminate when set VT has been delivered if before set time or it may terminate when excess flow demand abates, if after set time.

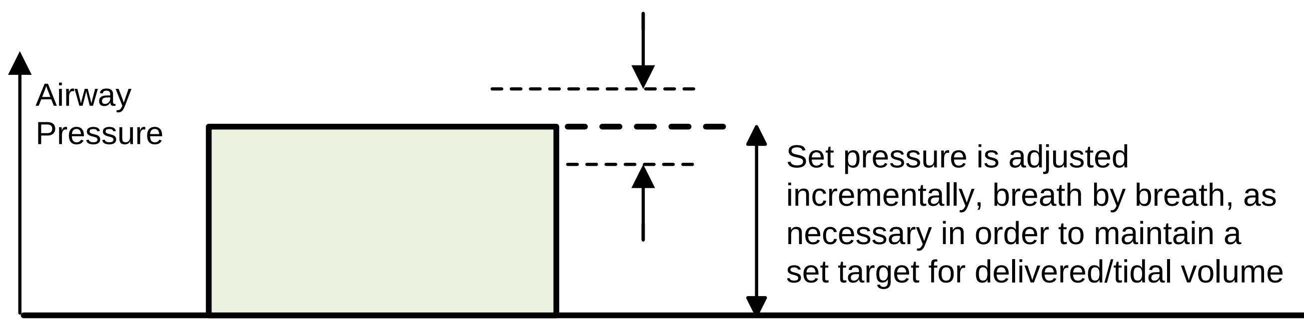
Effects on outcomes of settings and patient variables with VC breath-types



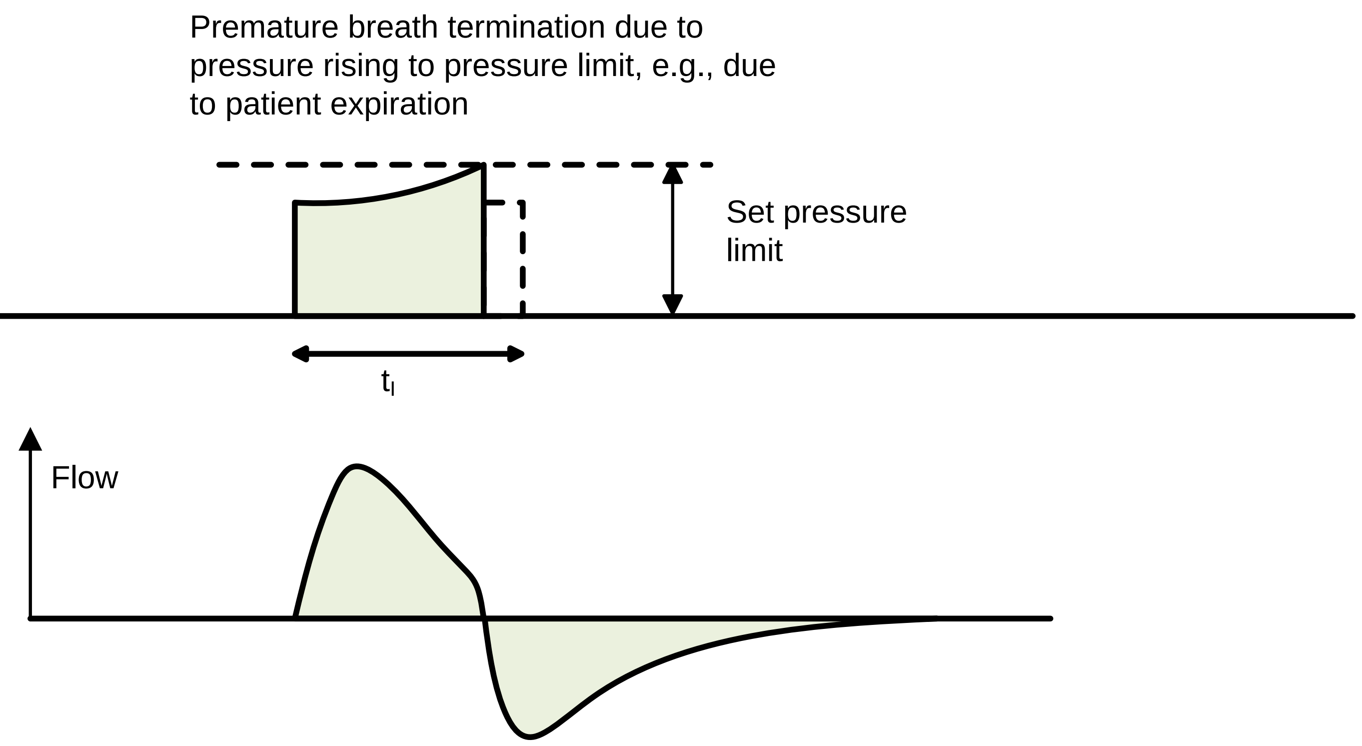
PC Breath-types



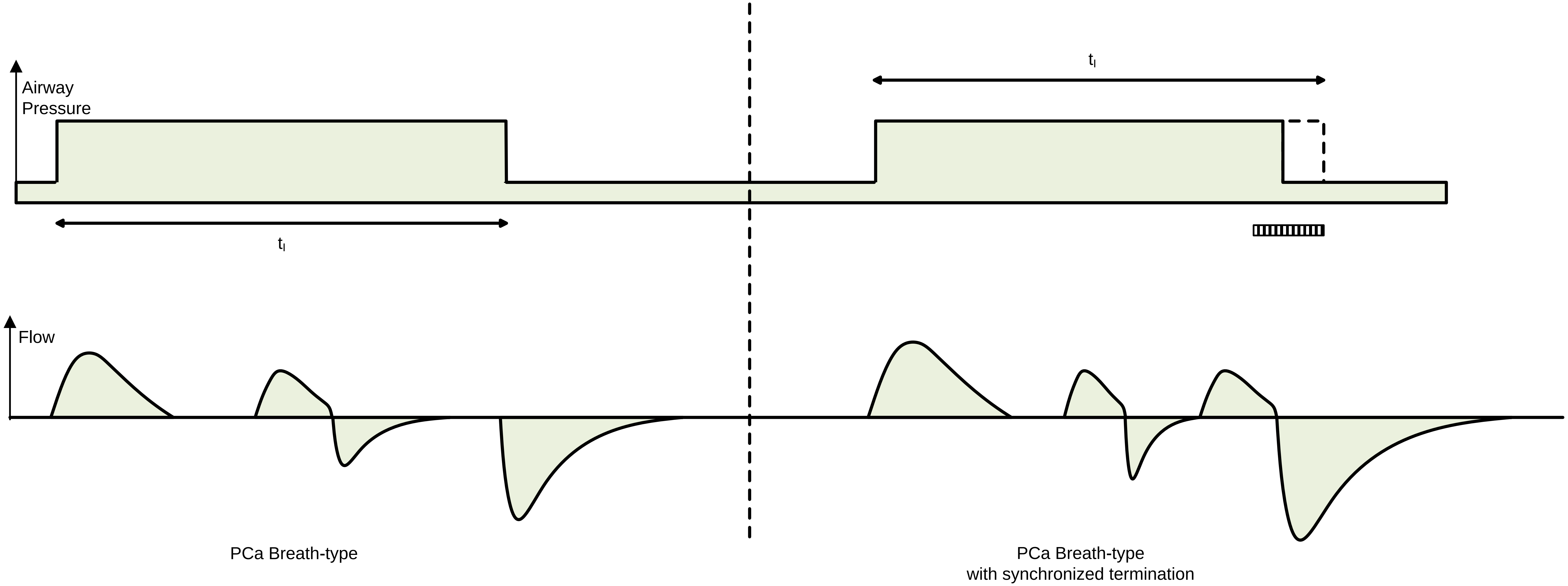
Breath-by-breath volume-targetting



Pressure limit

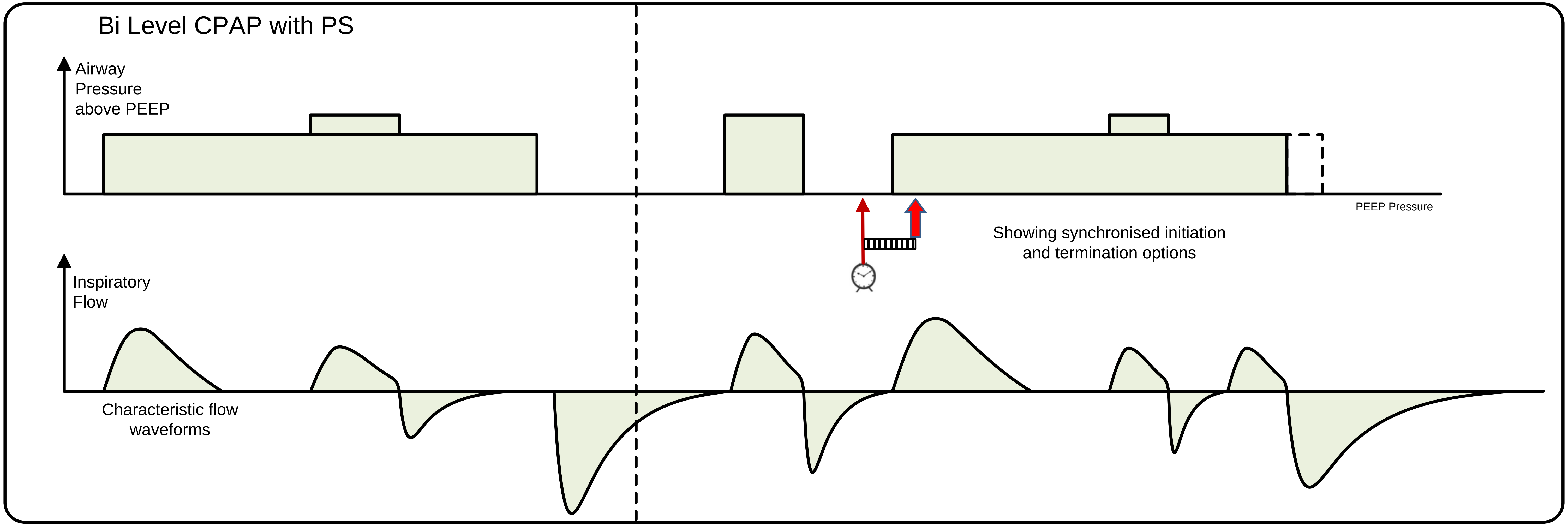


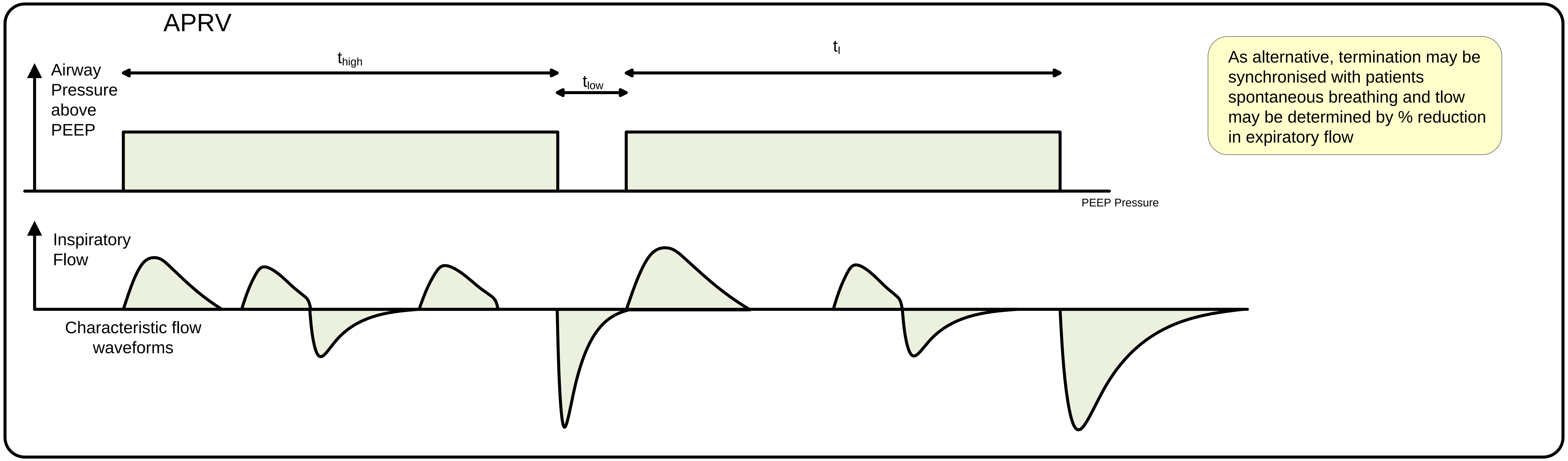
PCa Breath-types



Functions of Mode-types Based on PCa Breath-types

Group (ii) Mode-types





Concurrent breaths

The previous slides show waveforms for PCa breath-type deliveries with illustrative concurrent spontaneous breaths. In practice there could be several spontaneous breaths and they could take many forms. On the right are shown two other possible flow waveforms and these raise the question of what a breath is in this situation.

The generally accepted definition of a breath and its components is shown on page 2. Using that terminology the flow waveform A shows the delivered volume as a result of the increase in pressure due to breath-type a as the area b. The expired volume is shown by the area c. It is therefore clear that b & c represent the breath due to the delivered breath-type and d & e represent a concurrent spontaneous breath.

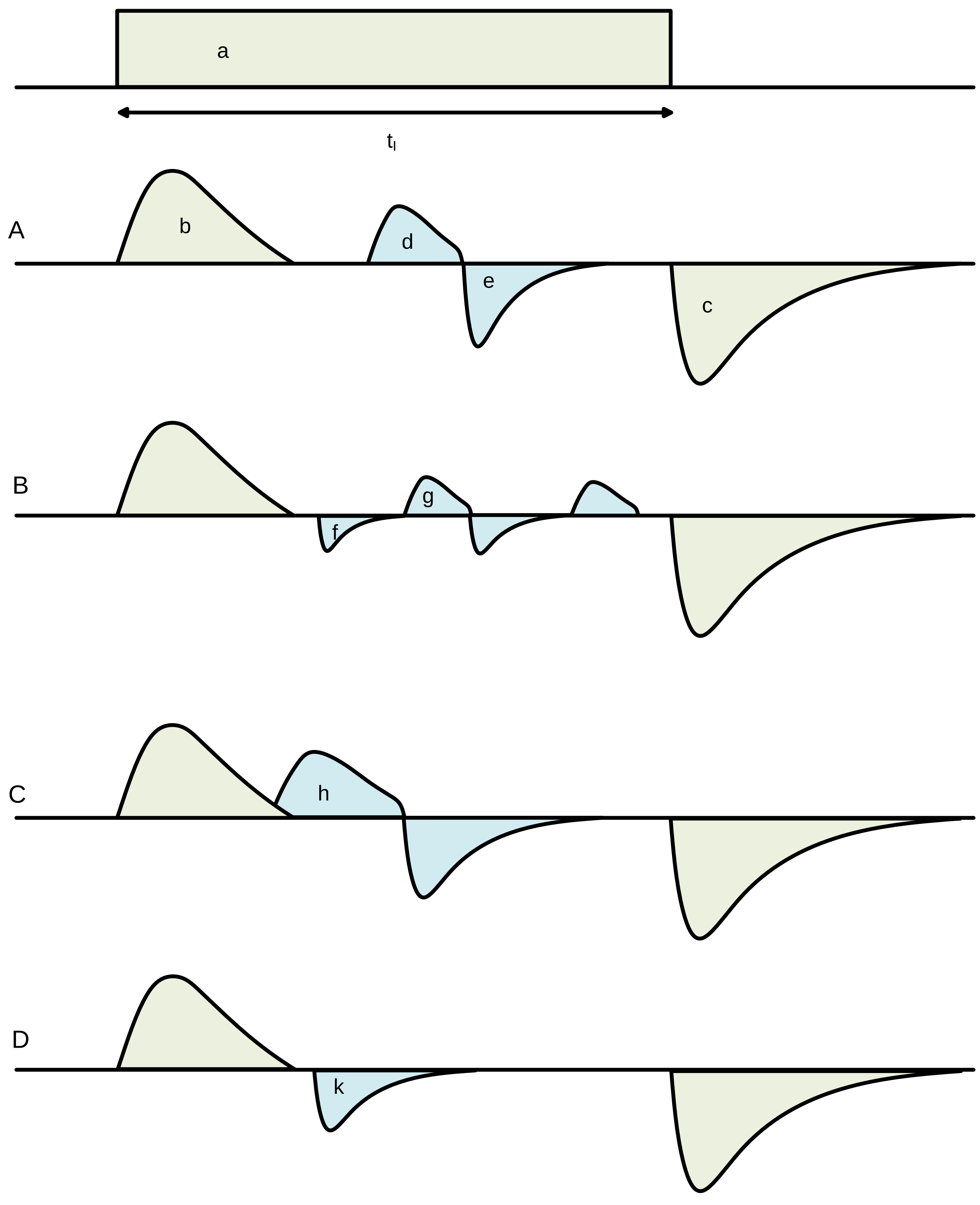
Waveform B shows a spontaneous exhalation before an inspiration. To do this the patient would have to have made an active expiratory effort but this is a possible occurrence and in this case the forced exhalation coupled with the inspiration still constitutes the requirement for a breath. The complete waveform therefore shows the result of the breath-type delivery and two concurrent spontaneous breaths.

Waveform C shows the patient's efforts augmenting the delivered volume resulting from the applied breath-type, and subsequently exhaling it, but there is no spontaneous breath because the inspiratory component is not independent of the ventilator imposed component.

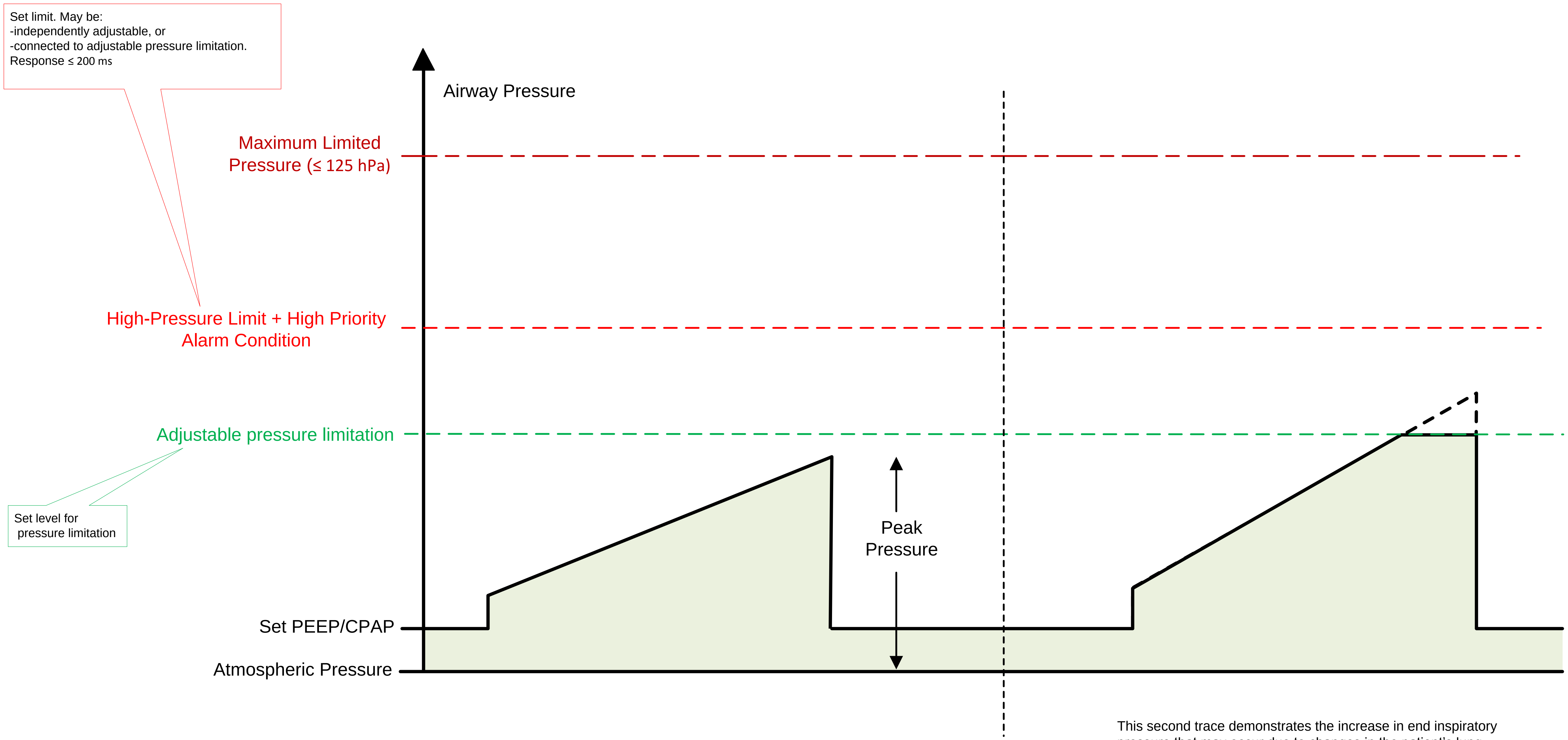
Waveform D shows a reflexive expiration during the flow pause following the imposed delivered volume. As in the previous example because k is not associated with a specific inspiration it does not constitute part of a new, spontaneous, breath.

From these examples we must create additional rules to identify separate breaths in situations where concurrency is possible. A proposed addition is:

> ***A concurrent breath:*** *is identified as starting and finishing with a flow of less than 5% of the immediately preceding peak flow and crossing the zero flow baseline at least once in between.*

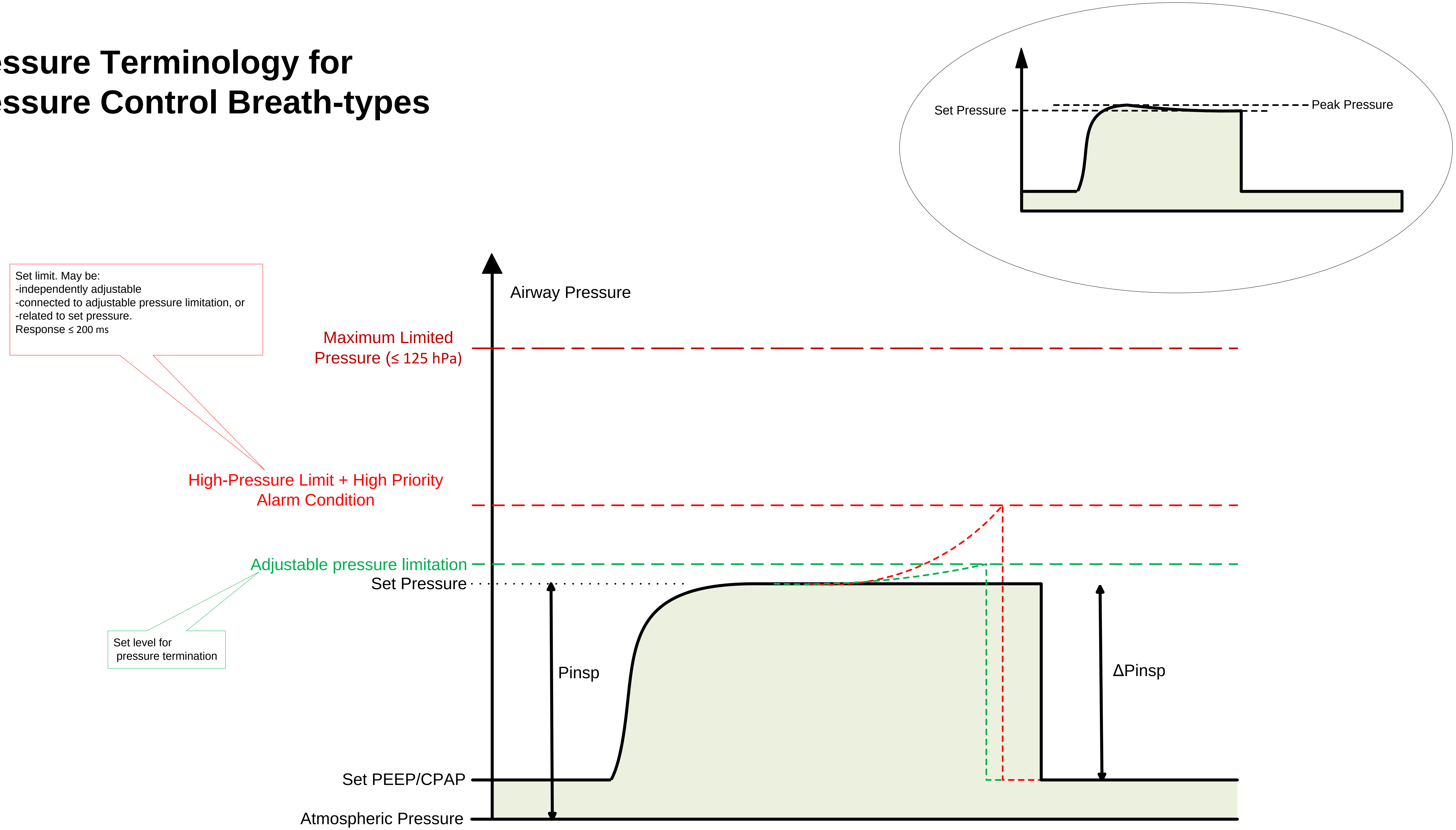


Pressure Terminology for Volume Control Breath-types



This second trace demonstrates the increase in end inspiratory pressure that may occur due to changes in the patient's lung characteristics while being ventilated with a VC breath-type. The set pressure limitation ensures that even with such changes the lung is protected from excessive pressure without creating a nuisance by generating alarms unless the consequent loss of delivered volume becomes excessive.

Pressure Terminology for Pressure Control Breath-types



Mode-type Groups

All mode-types can be conveniently classified into one of three groups:

***Group (i) Modes**: A single breath-type is selected. In the absence of spontaneous occurrences, breaths will be delivered mandatorily at a set frequency as result of the periodic assured occurrences of this selected breath-type. With modes in this group that respond to spontaneous occurrences the selected breath-type will be delivered in response to every such occurence between assured breath deliveries. Because the resultant breath frequency can be much higher than that set for assured deliveries it has become a common practice to designate the resultant breaths as 'assist' if patient initiated – as used in the currently used mode name A/C. Breaths that are delivered at the set frequency are mandatory breaths. With this definition, modes that cannot respond to spontaneous occurrences become CMV and modes that can respond become A/M (instead of A/C).*

***Group (ii) Modes**: A selected breath-type will be mandatorily delivered, instigated by the periodic generation, at the set frequency, of assured occurrences. These deliveries may be synchronised with spontaneous occurrences but the average rate of breath-type delivery is always the set rate. In the interval between the assured breath deliveries the patient is unimpeded in taking assisted or unassisted spontaneous breaths. Any such assistance is provided by the delivery of a second, assist, breath-type - initiated by the detection of a spontaneous occurrence.*

***Group (iii) Modes**: No breaths occur mandatorily. All breaths are spontaneous and may be either assisted by the delivery of a selected, assist, breath-type or unassisted. Unassisted breaths are intended to be unimpeded and this objective may be aided by the use of attributes such as TC where the intention is solely to minimise any imposed work of breathing and not to assist the natural (spontaneous) breath. Unassisted natural breathing may be at a set CPAP and with an elevated FiO_2.*

Note: If a breath-type that allows free spontaneous breathing at any time in the breath cycle is selected for use with any mode-types that involve assured deliveries then if the manufacturer provides access to select a second breath-type it is classified as a Group (ii) mode-type but if only one breath-type is selectable it is classified as a Group (i) mode-type.

Mode-type algorithms

MMV -- Minimum minute ventilation: All modes that provide assured occurences assure the operator that the patient will receive a minimum minute ventilation but in practice the term has been used to describe specific mode algorithms that automatically regulate one or more of the ventilator control parameters in order to achieve MMV with minimum intrusion on the patient's spontaneous breathing. The term is therefore not specific and must be accompanied by additional information before it can be classified. The two most commonly used MMV algorithms have been provisionally named as MMV(1) & MMV(2).

MMV(1): This is a control algorithm added to a SIMV mode-type. It monitors the delivered (or exhaled) minute volume and continuously adjusts the set frequency of the assured deliveries to the minimum necessary to maintain the set MMV.

MMV(2): This is a control algorithm added to a Group (ii) mode-type. It monitors the delivered (or exhaled) minute volume and the patient’s breathing frequency, and continuously adjusts the set frequency and inspiratory pressure of a PC(f,t) breath-type to maintain the set MMV in accordance with the Otis equation.

Mode Names

Mode-types				Breath-types	Modes		
Generic Mode-type	**Mode-type Group**	**Other Names Used**	**Generic Algorithmic Sub-set**	**Applicable Generic Breath-types**	**Composition of Mode**	**Generic Mode Name**	**Other names used**
CMV	Group (i)	IPPV		All Breath-type(s) that do not	CMV + Bt	CMV - Bt	See separate table for
A/M	Group (i)	A/C		permit concurrent exhalation.	A/M + Bt	A/M - Bt	specific combinations
SIMV	Group (ii)		MMV(1)&(2)	Bt1	SIMV + Bt1 Bt2	SIMV - Bt1 Bt2	of Mode-types &
CSV	Group (iii)	CSB, Spont		Bt Bt2	CSV + Bt	CSV - Bt	Breath-types
CMV	Group (i)	IPPV		Pressure control Breath-type(s)	CMV + Bt	CMV - Bt	
A/M	Group (i)	A/C		that do permit concurrent	A/M + Bt	A/M - Bt	
SIMV	Group (ii)		MMV(1)&(2)	exhalation, i.e., PCa & vtPC	SIMV + Bt Bt2	SIMV - Bt Bt2	
CSV	Group (iii)	CSB, Spont		Bt	CSV + Bt	CSV - Bt	`
Bi Level CPAP	Group (ii)				SIMV + Bt Bt2 IMV + Bt Bt2	Bi Level CPAP - Bt2	Biphasic, APRV, Inverse Ratio Biphasic

***Mode**: a specific, identifiable pattern of ventilator-patient interactions. A mode can be a general ventilatory pattern comprised of a mode-type and its associated selected breath-types (eg, CMV-VC) or a proprietary name (eg, SmartCare®)*

Manufacturers Mode Name	Mode-type	Breath-type (1)	Breath-type (2)	General
AC PCV	A/C	PC	N/A	
APV	CMV (or SIMV)	vtPCa		Breath-type only
APRV	Bi Level CPAP	PCa	PS	Inverse I:E
ASV	MMV(2)	vtPCa	None	
APV SIMV	SIMV	vtPCa	PS	
Assist/Control	A/C	VC	N/A	
BiLevel	Bi Level CPAP	PCa	None	
BiPAP S/T	A/C	PS/PC	N/A	Breath-type depends on cause of initiation
BiPAP S	CSV (Spont)	PS	N/A	
BIPAP (Biphasic PAP)	Bi Level CPAP	PCa	PS	
CMV	CMV	VC	N/A	
CMV + Autoflow	CMV	vtPC	N/A	
CPAP	CPAP	None	N/A	
DuoPAP	Bi Level CPAP	PCa	PS	
Flow Adaptive VC	A/C?	vtPC	N/A	
Mandatory Minute Ventilation	MMV	VC	PS	
PC-A/C	A/C	PC	N/A	
PCV+	A/C?	vtPC?	N/A	
Pressure Control	A/C?	PC	N/A	
Pressure Regulated VC	A/C?	vtPC	N/A	
Pressure Support	CSV (Spont)	PS	N/A	
Proportional Assist Ventilation	CSV (Spont)	PPS	N/A	
SIMV PCV	SIMV	PC	None	
SIMV + Autoflow	SIMV	vtPC	None	
S(CMV)	A/C	VC	N/A	
S(CMV)+	A/C	vtPCa	None	
VC + A/C	A/C	VC	N/A	
VC + SIMV	SIMV	VC	None	
VC-A/C	A/C	VC	N/A	
VC-SIMV	SIMV	VC	None	
Volume Assured Pressure Support	CSV (Spont)	vtPS	N/A	
Volume Control	A/M or CMV?	VC	N/A	
Volume Support	CSV (Spont)	vtPS	N/A	
VV + SIMV	SIMV	VC?	PS	
Biphasic PAP	Bi Level CPAP	PCa	None	
PSIMV+	SIMV	PCa	PS	
SIMV+	SIMV	vtPCa	PS	
P-CMV	A/C	PCa	None	
P-SIMV	SIMV	PCa	PS	
VC-CMV	CMV	VC	None	
VC-MMV	MMV(1)	VC	PS	
PC-CMV	CMV	PCa	None	
PC-BIPAP	Bi Level CPAP	PCa	PS	
PC-SIMV	SIMV	PCa	PS	
PC-APRV	Bi Level CPAP	PCa	PS	
SPN-CPAP/PS	CSV (Spont)	PS	None	
SPN-CPAP/VS	CSV (Spont)	vtPS	None	
SPN-PPS	CSV (Spont)	PPS	None	
VCV	CMV	VC	None	
PCV	CMV	PC	None	
PCV-VG	CMV	vtPC	None	
A/C-VCV	A/M	VC	None	
A/C-PCV-VG	A/M	vtPC	None	
CPAP/PSV	CSV (Spont)	PS	PS	
SIMV-PC-VG	SIMV	vtPC	PS	
BiLevel-VG	BiLevel CPAP	vtPCa	PS	
SIMV-VT-PC	SIMV	vtPC	PS	
Bi-Vent	BiLevel CPAP	vtPCa	PS	
	8 types	*8 types*		
	Consisting of 3 main classes & 6 subclasses	Consisting of 2 main classes & 5 commonly used subclasses		

Additional Features

Other issues to be addressed:

Manual triggering
NIV
Special procedures e.g., suction, x-ray pause, sighs
Alarm conditions
Exhalation phase

Please Note: It is recognised that the terminology is often used pedantically in this handbook but the intention is to highlight the meaning of the terms. It is the intention that in everyday use the majority of existing terms will continue to be used but that manufacturers' instructions for use, and published literature, will always use these terms with the same interpretation.

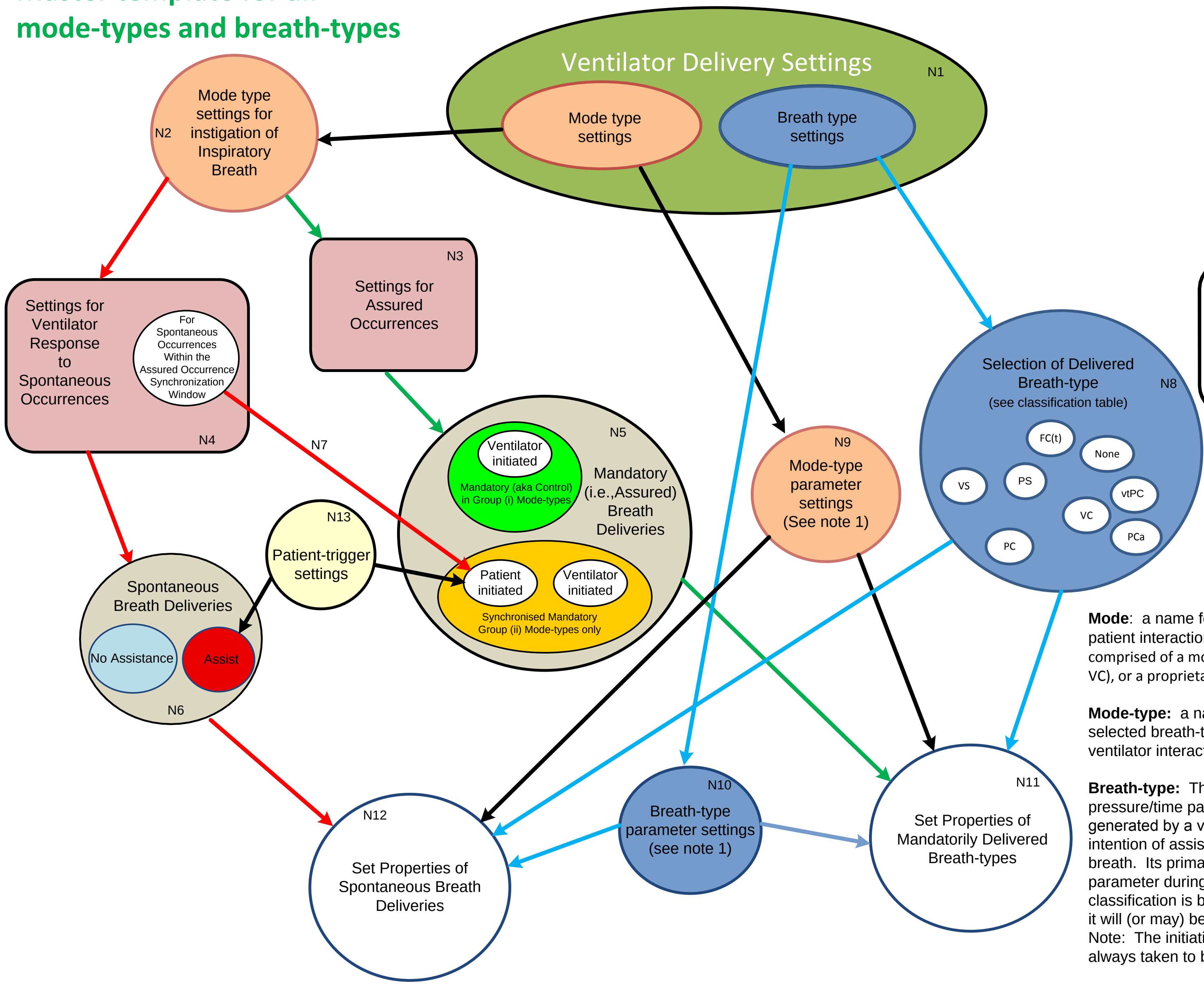
Master Template

As was described in the introduction the basic thought processes necessary in setting a ventilator have been incorporated into a universally applicable network diagram that shows the fundamental pathways that always have to be followed in the process of setting a ventilator to deliver any of the modes of operation that may be offered by the manufacturer. The arrows indicate the pathways and the coloured shapes show the options available for selection before moving on to the next shape. There are three basically parallel paths indicted by different coloured arrows; the red and green paths are associated with setting the mode-type and the blue path with setting the breath-type. The red path leads to the setting of assured occurrences and the green path to the setting of the response to spontaneous occurrences.

There are notes commenting on each node in the pathways and the following set of slides its application in setting a wide range of modes, both from the setting perspective and from the perspective of the observer of the subsequently displayed waveform.

In mapping out the thought processes in setting a ventilator this chart also shows the basis for the ontological framework underlying the terminology used in this presentation. Some new terms have had to be introduced in order to create classification distinctions that could not be made using established terms because of their unrestricted past usage. It is not expected that all of these new terms will have to be introduced into general usage but they will serve to impose a discipline on the use of established terms.

Master template for all mode-types and breath-types



Note1: The breath and mode-type parameters settings are settings which may be changed by the operator or may be adjusted continuously or incrementally, in accordance with the selected algorithm by using feedback from measured parameters

Mode: a name for a specific, identifiable pattern of ventilator-patient interactions. A mode can be a general ventilatory pattern, comprised of a mode-type and its associated breath-types (CMV-VC), or a proprietary name (E.g. SmartCare).

Mode-type: a name for a specific, identifiable pattern of when selected breath-types are applied and generally how the ventilator interacts with the patient.

Breath-type: The term used to delineate the elevated pressure/time pattern that is selected to be intermittently generated by a ventilator at the patient's airway with the intention of assisting or controlling the inspiratory phase of a breath. Its primary classification is by means of the controlled parameter during delivery, i.e., flow or pressure. Its secondary classification is by means of the criterion (or criteria) by which it will (or may) be terminated, e.g., time, flow, pressure.
Note: The initiation of the delivery of a selected breath-type is always taken to be a function of the selected mode-type.

Notes to Assist Use of Master Template

N1. As has been explained the setting of a ventilator starts with considering the settings for both the required mode-type and the required breath-type(s).

N2. In setting of the mode-type the first consideration is to decide whether any assured occurrences are required and whether there is a requirement to respond to any spontaneous occurrences. For assured occurrences the green path is followed and for the response to spontaneous occurrences the red path is used.

N3. If assured occurrences are required consideration has to be given to how and when they are instigated and which of the mode-types available on the ventilator can be utilised to achieve this pattern.

N4. If there is a requirement to respond to spontaneous occurrences consideration has to be given as to whether this response occurs in isolation or whether it is to be associated with assured deliveries. In particular, the response can be set such that if a Group (ii) mode-type has been selected then any spontaneous occurrence falling within the synchronisation window initiates the already instigated delivery.

N5. It is necessary to select a mode-type that generates the required pattern of assured occurrences and initiates the delivery of a breath-type(s) that will be selected from a set made available on the ventilator for use with that mode-type. Assured breath deliveries are classified as **mandatory** where they can only be initiated by the ventilator and **synchronised mandatory** where the already **instigated breath** delivery may be initiated by the patient to achieve **synchronisation** if the spontaneous occurrence exceeds the set patient trigger threshold.

N6. Where an independent response to spontaneous occurrences is required a decision has to be made as to whether the response should be to assist the ensuing spontaneous breaths or to provide a passive delivery to satisfy the demand with no assistance. Assist will only be initiated if the spontaneous occurrence exceeds the set patient trigger threshold.

N7. This arrow shows the path followed when the response to a spontaneous occurrence during a synchronisation window is set to initiate an already instigated assured delivery.

N8. Alongside the setting of the required mode-type the operator has to select the breath-type(s) that the selected mode-type will deliver following each initiation. The ontological framework allows any breath-type to be associated with any mode-type but practical and medical considerations may limit the scope of these associations; some of the more complex mode-types may only function with specific breath-types and some combinations may not be made available because they appear to offer no medical benefit.

N9. Before a selected mode-type can operate its associated parameters have to be set. In particular the frequency has to be set – either directly or by means of an associated algorithm.

N10. Before a breath-type can operate several of its associated parameters have to be set. Typical parameters are: delivered volume, inspiratory time, inspiratory pressure, % flow for termination, rise time & limiting pressure.

N11. All the settings that converge at this circle are those that assure the operator that a required level of ventilation will be mandatorily delivered when the ventilator is in operation.

N12. All the settings that converge at this circle are those that determine how the ventilator will respond to each detectable spontaneous breath.

N13. For a patient to be able to initiate an assist or synchronised mandatory breath delivery the spontaneous occurrence has to exceed the threshold settings of the patient trigger unit. The patient trigger unit is an independent function that is set to a selected method of detecting the commencement of a patient's breathing effort and provides a signal to the mode algorithm when this signal exceeds a set threshold.

Setting ventilation modes following the guidance provided by the master mode setting network diagram

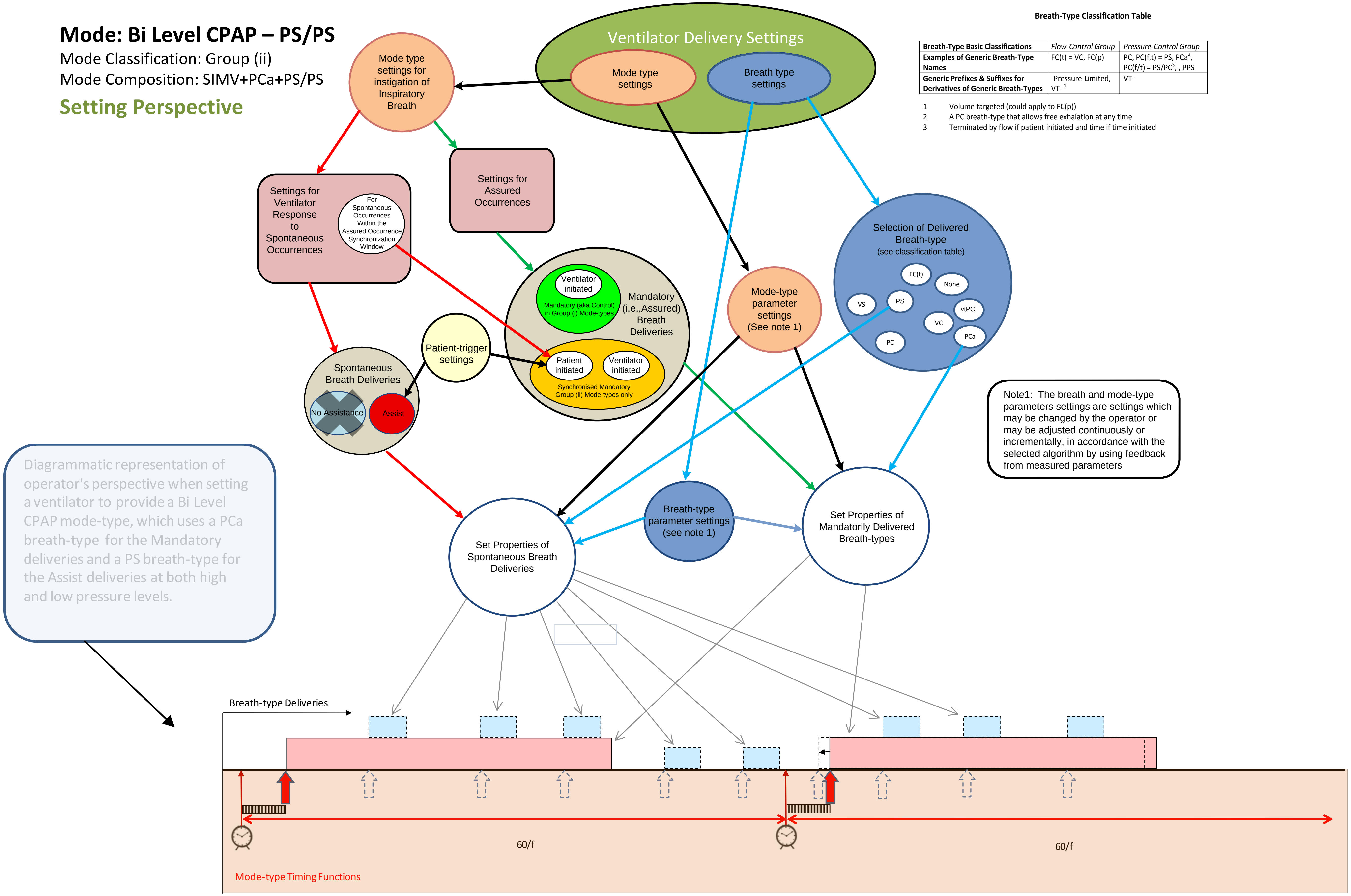
The following two pages show examples of how the master mode setting diagram can be used to guide the setting of any ventilation mode and how it can be used to interpret a typical outcome that the operator might expect from that setting. A comprehensive set of examples was circulated in two documents early in October but, although still basically applicable, these will need to be updated to bring them into line with this handbook before insertion.

Mode: Bi Level CPAP – PS/PS

Mode Classification: Group (ii)

Mode Composition: SIMV+PCa+PS/PS

Setting Perspective



Breath-Type Classification Table

Breath-Type Basic Classifications	*Flow-Control Group*	*Pressure-Control Group*
Examples of Generic Breath-Type Names	FC(t) = VC, FC(p)	PC, PC(f,t) = PS, PCa[2], PC(f/t) = PS/PC[3], , PPS
Generic Prefixes & Suffixes for Derivatives of Generic Breath-Types	-Pressure-Limited, VT- [1]	VT-

1 Volume targeted (could apply to FC(p))

2 A PC breath-type that allows free exhalation at any time

3 Terminated by flow if patient initiated and time if time initiated

Mode: Bi Level CPAP – PS/PS

Mode Classification: Group (ii)

Mode Composition: SIMV+PCa+PS/PS

Outcome from Setting

Breath-Type Classification Table

Breath-Type Basic Classifications	*Flow-Control Group*	*Pressure-Control Group*
Examples of Generic Breath-Type Names	FC(t) = VC, FC(p)	PC, PC(f,t) = PS, PCa[2], PC(f/t) = PS/PC[3], , PPS
Generic Prefixes & Suffixes for Derivatives of Generic Breath-Types	-Pressure-Limited, VT- [1]	VT-

1 Volume targeted (could apply to FC(p))

2 A PC breath-type that allows free exhalation at any time

3 Terminated by flow if patient initiated and time if time initiated